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THE CONTROL OF THE CODLING MOTH IN THE PECOS VALLEY IN NEW MEXICO.

By A. L. QUAINTANCE, *in Charge of Deciduous Fruit Insect Investigations.*

INTRODUCTION.

For some years complaints have been received by the Bureau of Entomology from the fruit growers in the Pecos Valley, N. Mex., of the severe injury to apples and pears by the codling moth (*Carpocapsa pomonella* L.). The methods employed in the control of this insect in other apple-growing regions have, in the Pecos Valley, been stated to be there much less efficient, so that a considerable portion of the crop of fruit has been wormy and unsalable.

The codling moth should yield as readily to treatment in the Pecos Valley as elsewhere, though, owing to favorable climatic conditions, it was surmised that it might develop an additional generation. It was not believed, however, that the behavior of the insect in that region was essentially different from its behavior in other sections, and the lack of satisfactory results from spraying operations, it was thought, probably resulted from failure to accomplish this work in a thorough and timely manner.

Beginning in the spring of 1912 an investigation of the codling moth was undertaken by the Bureau of Entomology, with headquarters at Roswell, N. Mex., and Mr. A. G. Hammar, who had had much experience with this insect at other field stations of the bureau, was assigned to the work. During that year he was assisted by Mr. Earl R. Van Leeuwen, and during 1913 by Mr. L. L. Scott and Mr. E. W. Geyer. Owing to the unfortunate death of Mr. Hammar there devolves upon the writer the necessity of preparing for publication, for the benefit of the Pecos Valley fruit growers, the results of Mr. Hammar's experiments. The investigations carried out by Mr. Hammar comprise a thorough inquiry into the life history and habits of the codling moth in that region, and experiments with sprays in orchards. The results of the life-history studies will be given in another paper.

NOTE.—This bulletin describes the codling moth as it affects fruit growing in the Pecos Valley, N. Mex. It is of interest to fruit growers in the Southwest.

The present article deals with results obtained in spraying in 1913. Work was carried out in two orchards, namely, that of Messrs. Sherman & Johnson and that of Mr. Robert Beers. Unfortunately the report of results in the latter orchard is not entirely complete, so that the details of these experiments can not be given. In general, however, the results obtained in the Beers orchard agree with those secured in the Sherman & Johnson orchard, and the latter are given in detail in the following pages.

EXPERIMENTS IN THE SHERMAN & JOHNSON ORCHARD.

A portion of the Sherman & Johnson orchard, about 5 acres in extent, was selected for spraying experiments and was subdivided into plats, as shown in figure 1.

The trees were large, and codling-moth conditions were fairly typical for the valley. Plat I received three applications; Plat II, four applications; and Plat III, five applications of arsenate of lead spray. Plat IV was left unsprayed throughout the season for purposes of comparison. A good power sprayer was used, capable of supplying three or four leads of hose, and maintaining a pressure of 200 to 225 pounds. (See fig. 2, showing outfit in operation, and size of trees used.) Further information concerning the treatments and the dates of spray applications for the respective plats is given in Table I.

TABLE I.—*Treatments and dates of applications of sprays for codling moth, Sherman & Johnson orchard, Roswell, N. Mex., 1913.*

Dates of applications.	Plat I (3 applications).	Plat II (4 applications).	Plat III (5 applications).	Plat IV (unsprayed).
Apr. 24–25 (After falling of petals.)	Arsenate of lead, 6 pounds to 200 gallons of water. Bordeaux nozzles. 16½ gallons per tree. 225 pounds pressure.	Arsenate of lead, 6 pounds to 200 gallons of water. Bordeaux nozzles. 16½ gallons per tree. 225 pounds pressure.	Arsenate of lead, 6 pounds to 200 gallons of water. Bordeaux nozzles. 16½ gallons per tree. 225 pounds pressure.	Unsprayed.
May 7–8	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 13¾ gallons per tree. 200 pounds pressure.	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 13¾ gallons per tree. 200 pounds pressure.	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 13¾ gallons per tree. 200 pounds pressure.	Do.
June 16–17	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 15¾ gallons per tree.	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 15¾ gallons per tree.	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 15¾ gallons per tree.	Do.
July 14–15		Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 17¼ gallons per tree.	Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 17¼ gallons per tree.	Do.
Aug. 2			Arsenate of lead, 8 pounds to 200 gallons of water. Vermorel type nozzles. 9⅓ gallons per tree.	Do.

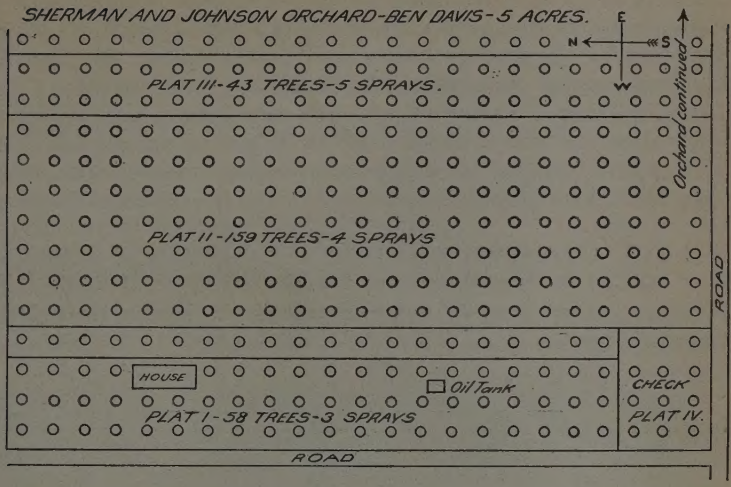

FIG. 1.—Diagram showing arrangement of trees used in codling-moth experiments, Sherman & Johnson orchard, Roswell, N. Mex. (Original.)

FIG. 2.—View in Sherman & Johnson orchard, Roswell, N. Mex., showing size of trees and power sprayer in operation. (Original.)

It will be noted from Table I that the amount of spray used in all applications was large, and probably considerably in excess of that used by the average fruit grower in the valley. The amount of spray applied immediately following the falling of the petals (April 24–25) exceeded somewhat the amount given in any subsequent application. It will be noted also that Bordeaux nozzles were used at this time, whereas in subsequent treatments the so-called eddy chamber or Vermorel type of nozzle was used, producing a fine cone-shaped spray.

In Table II are shown the number and percentage of sound fruit from each of five trees of each plat, as well as the total number and total percentage of sound and wormy fruit for the five trees of the respective plats.

TABLE II.—*Number of sound and wormy apples from each tree of each plat, Sherman & Johnson orchard, Roswell, N. Mex., 1913.*

Plat and condition of fruit.	Tree 1.	Tree 2.	Tree 3.	Tree 4.	Tree 5.	Total fruit for plat.	Total per cent sound fruit.
Plat I.							
Wormy	138	144	153	179	152	766	
Sound	2,918	2,022	3,382	3,418	3,239	14,979	
Total	3,056	2,166	3,535	3,597	3,391	15,745	
Per cent sound	95.48	93.35	95.67	95.02	95.52	.....	95.13
Plat II.							
Wormy	86	39	33	37	70	265	
Sound	4,271	4,086	3,378	3,344	5,504	20,583	
Total	4,357	4,125	3,411	3,381	5,574	20,848	
Per cent sound	98.02	99.05	99.03	98.90	98.74	.....	98.72
Plat III.							
Wormy	51	18	40	25	14	148	
Sound	6,283	4,479	4,494	4,618	4,442	24,316	
Total	6,334	4,497	4,534	4,643	4,456	24,464	
Per cent sound	99.19	99.59	99.12	99.46	99.68	.....	99.39
Plat IV.							
Wormy	5,308	2,671	3,813	3,486	3,336	18,614	
Sound	2,871	2,349	2,873	2,765	1,958	12,816	
Total	8,179	5,020	6,686	6,251	5,294	31,430	
Per cent sound	35.12	46.79	42.97	44.23	37.03	.....	40.77

It will be seen that Plat I, which received a total of three applications of an arsenate of lead spray, gave 95.13 per cent sound fruit. Plat II, with four applications, yielded a somewhat higher quantity of sound fruit, namely, 98.72 per cent; while from Plat III, which received five spray applications, 99.39 per cent of the fruit for the season was sound. Plat IV, which was not sprayed during the season, shows only 40.77 per cent of the fruit free from codling moth injury. In determining these results, examinations were made as to worminess of all the apples produced on the five count trees throughout the season; that is, the fruit which fell, the fruit which was picked from the trees in thinning, and that picked at harvest time.

It would appear that with the minimum of three applications, made as shown in Table I, injury from the codling moth in the Pecos Valley may be reduced to less than 5 per cent of the total crop of apples produced. For each of the two additional applications an increase in sound fruit is shown, but probably not in proportion to the expense involved. It should be borne in mind, however, that in these experiments applications were made with much thoroughness, and unless the orchardist will do equally as thorough work it will be better for him to make the additional applications.

PLACES OF ENTRANCE OF FRUIT BY CODLING MOTH LARVÆ.

Many observations in different parts of the country have shown that the majority of codling moth larvæ normally enter the apple at

FIG. 3.—Showing condition of calyx lobes of Ben Davis apple: *a*, Two days after falling of petals; *b*, ten days after falling of petals. (Original.)

the calyx end. A careful study of the places of entering sprayed fruit by larvæ, whether at calyx, side, or stem, throws much light on the relative effectiveness of the respective spray applications. All experiments corroborate the statement that the treatment given immediately after the falling of the petals is by far the most important one and that its omission can not be corrected by subsequent treatments, however thoroughly made.

A study of the behavior of the calyx lobes of the recently set apples in the Roswell section furnishes evidence of value in timing spray applications. Ordinarily in the East there is a period of about 10 days following the dropping of apple blossoms during which the

calyx lobes remain open, so that the spray may be successfully directed into the calyx cups. In New Mexico, however, it would appear that the calyx lobes of the little apples do not draw together nearly so quickly after the falling of the petals and may remain open in suitable condition for calyx spraying for a period of from two to three weeks, varying somewhat with the variety and season. (Figs. 3 and 4.)

This condition renders it possible to apply the second spray in a way to supplement the first spray into the calyx cups.

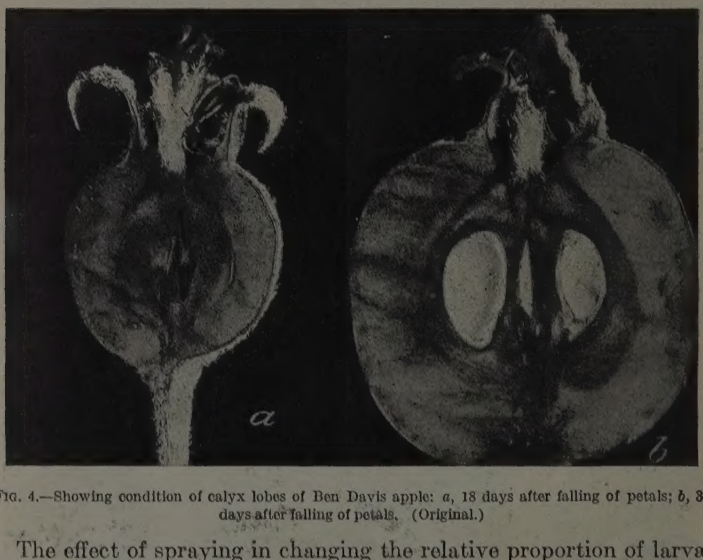

FIG. 4.—Showing condition of calyx lobes of Ben Davis apple: *a*, 18 days after falling of petals; *b*, 30 days after falling of petals. (Original.)

The effect of spraying in changing the relative proportion of larvæ which succeed in entering the fruit at the calyx, side, and stem is shown for Plats I to III in Table III. The normal behavior of the larvæ in entering the fruit may be seen by referring to the figures for Plat IV of this table. It will be noted that on the unsprayed plat somewhat over one-half (53.72 per cent) of the total larvæ for the season entered the fruit at the calyx end.

TABLE III.—*Number and percentage of codling moth larvæ entering fruit at calyx, side, and stem for Plats I–IV, Sherman & Johnson orchard, Roswell, N. Mex., 1913.*

Total larvæ for plat for season entering at—	Plat I.	Per cent.	Plat II.	Per cent.	Plat III.	Per cent.	Plat IV.	Per cent.
Calyx	19	2.31	17	6.27	10	6.76	12,663	53.72
Side	789	96.45	249	91.88	128	86.48	9,622	40.82
Stem	10	1.24	5	1.85	10	6.76	1,285	5.46
Total	818	100.00	271	100.00	148	100.00	23,570	100.00

This table also shows the destructive influence of sprays in lessening the actual number of larvæ. Thus on Plat I, which received three sprays, there was a total of 818 larvæ for the season, on the five count trees; on Plat II, which received four sprays, the number of larvæ for the five trees was 271; while on Plat III, which received five sprays, only 148 codling moth larvæ were found in fruit from the five "count trees" during the year. The foregoing figures are in marked contrast with the total number of larvæ found in fruit from the five unsprayed trees, namely, 23,570.

RECOMMENDATIONS BASED ON THE FOREGOING RESULTS.

While the results reported herewith are very clear-cut, the bureau would not be warranted in formulating definite recommendations based upon the work thus far carried out in the Pecos Valley were it not for the reason that these results substantiate the results obtained from a large series of spraying experiments against the codling moth in many parts of the United States. In Table I, showing treatments and dates of applications, the reader will note that the first applications were made with Bordeaux nozzles and the later applications with eddy chamber nozzles. Entomologists of certain Western States who have experimented with the codling moth under arid conditions insist upon the advantage of a coarse spray given at the time immediately following the dropping of the petals. Tests of the comparative value of coarse and fine sprays under eastern conditions show that there is apparently but little difference as regards the effectiveness in the control of the insect of a coarse and fine spray. The Roswell experiments did not include a comparison of coarse and fine sprays and no specific information can be furnished on this point, and it would appear safer for the orchardist to follow the methods used by Mr. Hammar until further information is obtained. It will also be noted that spraying was done under high pump pressure. This should not be construed to mean that effective work in the control of the codling moth can not be accomplished except by use of power outfits working at high pressure. Very good results have been obtained from the use of barrel sprayers working at perhaps 100 to 120 pounds pressure.

The prime essential in the control of the codling moth is that the treatment given immediately after the falling of the blossoms shall be made with great thoroughness, in order to insure the lodgment of poison in the calyx cup of each and every apple. This result is best secured by so handling the spray rods that the spray is directed downward into the upright clusters of the little apples. This spraying especially should be made rather deliberately and with great pains. Frequent examination of sprayed trees should be made to determine how thoroughly calyx cups are being filled with poison.

First application.—As soon as the petals have fallen, spray the trees with arsenate of lead, using the poison at the rate of 6 pounds to 200 gallons of water. Direct the spray straight into the calyx cups, for which purpose an elbow or crook should be used on the end of the spray rods. In spraying high trees a tower is indispensable, as shown in figure 2.

Second application.—About two weeks after the falling of the petals spray with arsenate of lead at the rate of 8 pounds to 200 gallons of water. Make an effort to apply this spray before the calyx lobes are more than three-fourths closed, which may be determined by careful examination in the orchard. (See fig. 3.) Direct this spray, also, as much as possible straight into the calyx cups, and at the same time take care to coat the leaves and fruit.

Third application.—Eight or nine weeks after the falling of the petals spray again with arsenate of lead at the rate of 8 pounds to 200 gallons of water. In this treatment cover the foliage and fruit as uniformly as possible with the poison.

Subsequent applications.—The three applications specified, if thoroughly made, should effectively control the codling moth, as shown by the results of experiments herewith reported. If these applications have not been thoroughly made, and it is seen that the codling moth will do considerable injury, additional applications will doubtless be desirable to check the insect as much as possible. Thorough work, especially in applying the first and second applications, should largely obviate the necessity for more than three treatments.

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